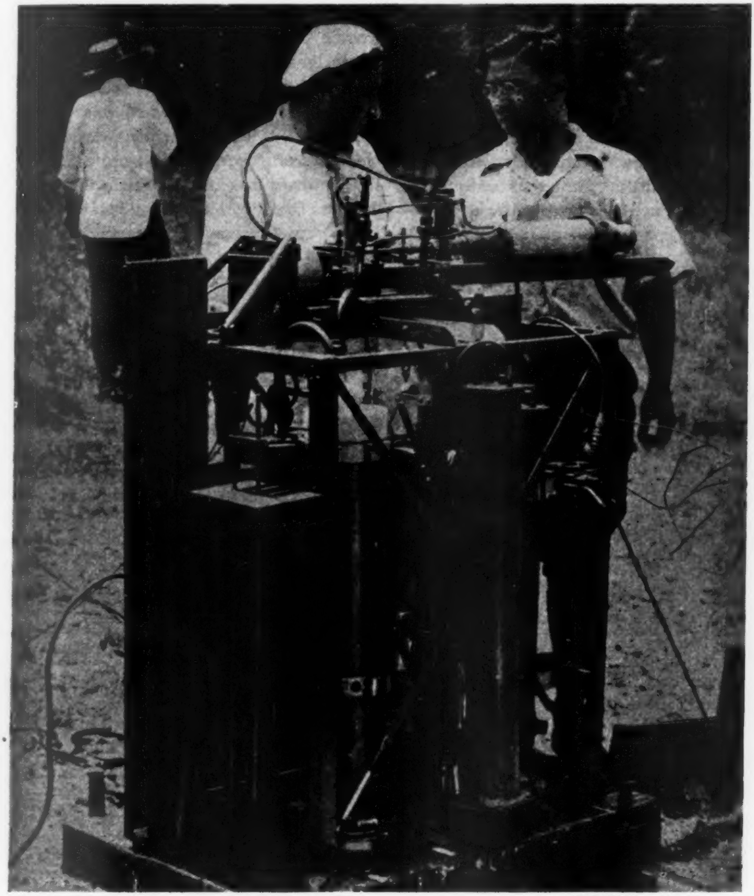
ASTRONAUTICS

Journal of the American Rocket Society

Number 50 October, 1941



HECHT

NEW THRUST RECORD—Alfred Africano (right) discusses the performance of his motor with Louis Goodman. The motor had just given a peak thrust of over 260 lbs. Report on Page 3.

THE AMERICAN ROCKET SOCIETY

was founded to aid in the scientific and engineering development of jet propulsion and its application to communication and transportation. Three types of membership are offered: **Active,** for experimenters and others with suitable training; **Associate,** for those wishing to aid in research and publication of results, and **Junior,** for High School Students and others under 18. For information regarding membership, write to the Secretary, American Rocket Society, 1 East 42nd Street, New York City.

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NOTES AND NEWS

High on a list of inventions wanted by the government for use in national defense is the item "rocket-powered projectiles." Jet propulsion for explosive shells would eliminate cumbersome and costly cannon; make practicable the use of super-sensitive high explosives; do away with recoil effect on warships and possibly bring about the realization of radio-controlled aerial torpedoes. Members with ideas along this line are urged to forward them to the National Inventors Council at Washington, D. C. All suggestions will receive careful study by technical experts.

Rocket planes have been claimed by England (Whipple) and Italy (Campini). Now comes work of a German jet motor (reported elsewhere in this issue) for use in high speed aircraft. All three designs use atmospheric air under slight compression burned with fuel and exhausted to give rocket thrust. The editor is very skeptical of the ability of motors of this type to successfully compete with present aircraft engines.

It is an unfortunate fact that a great many of our members do not possess a technical background. This is reflected in their letters of inquiry asking for clarification of some point or theory connected with rocket work. Others, who seemingly have forgotten their elementary physics, advance theories and ideas which are at variance with known physical laws. With democratic liberality we have even printed articles which did not reflect the views

(Continued on Page 16)

Report On Motor Tests Of June 22

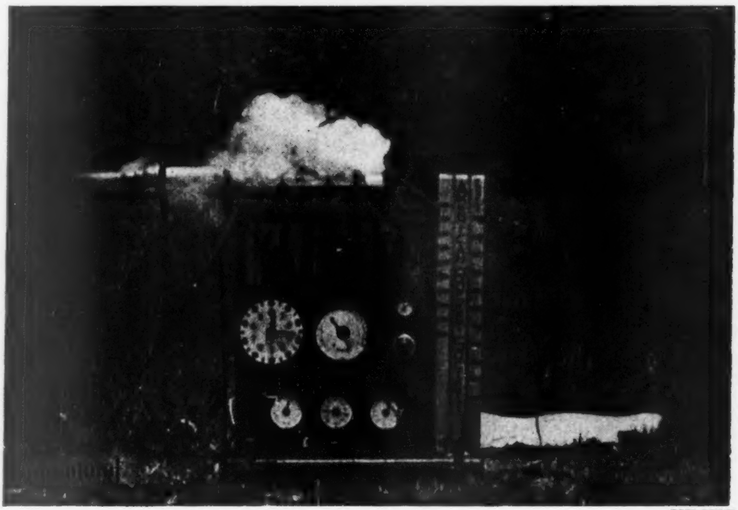
New Records for Thrust and Duration

Two new American Rocket Society records were set during the hot Sunday afternoon of June 22 at the Society proving grounds at Midvale, N. J. A peak thrust of over 260 lbs. was attained by the refractory lined motor of Mr. Alfred Africano and a run of 48 seconds duration was made by a small water cooled unit. A third motor, submitted by Mr. Robert Youngquist of M. I. T., unfortunately exploded at the end of its run. The cause of the mishap has not as yet been fully ascertained.

Africano Motor Test

After going through the usual setting up and checking of the test stand and motor a gallon of denatured alcohol and approximately 13 lbs. of liquid oxygen were put in the tanks. Signals were given by H. F. Pierce to open the nitrogen bottle for pressure feed, then ignition was effected. With an ear-splitting roar the motor fired. Immediately the pointer rose, then fell back momentarily before beginning its steady path around the dial. This initial jump and drop back is an interesting phenomenon seen also in the performance of other motors. It is probably caused by an initial explosion which produces a pressure wave and temporarily shuts off the flow of fuel.

Around the dial crept the pointer, past the final 200 lb. mark, and through the blank segment until it was brought to a halt by the stop pin. It remained



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The Africano Motor Firing—2½ seconds after ignition the thrust pointer indicates about 85 lbs. Cloud of oxygen vapor denotes leaking fittings.

here for about 2 seconds then began to move back until at the end of 12 seconds of firing it fell off to zero.

The exact peak reaction of this test will never be known due to the limitation of the guage, but it can safely be said that it exceeded 260 lbs. for about 2 seconds. The reaction gauge was subsequently taken to the shop for overhauling. Tests there showed that the instrument was bady strained during the run and lost its accuracy.

During the run, just prior to and continuing as reaction reached its peak, a great deal of the ceramic lining flew out of the nozle. This undoubtedly had some effect on the performance as it increased both the effective nozzle area and the weight of jet flow. Due to these unknown factors and the constantly changing reaction it is extremely difficult to make an accurate calculation of jet velocity.

Combustion during the run appeared quite even except for a few chugs which sent distinct vibrations through the air. It was generally agreed that the motor performed very well, due to care taken in design. It is hoped Mr. Africano can secure a more erosion resistant material for lining the motor, for further tests are necessary before evaluation of performance can be made. A new thrust gauge calibrated to 500 lbs. will shortly be installed on the test stand.

Between Runs

After the commotion, caused by the record breaking thrust of the Africano motor, and also by the small field fires started by the ejected ceramic, had died down a halt for lunch was called. Here the services of the Refreshment Committee was utilized to the gastronomic delight of all present.

GREENE

Robert Youngquist and M.I.T. Motor

The M. I. T. Motor

From Massachusetts Institute of Technology had come Mr. Robert Youngquist bearing an extremely sturdy appearing motor built by himself and a few others of the newly formed M. I. T. Rocket Club. Originally scheduled for testing on the 8th of June but postponed due to a shortage of oxygen on that date, this test run was anticipated with great interest by the Experimental Committee. The design was ingenious if unorthodox, employing the liquid oxygen to cool the lower part of the chamber and the nozzle. After passing through this jacket the oxygen was sprayed upward, through an annular injector, to meet a similar spray of alcohol. Provision was made for tapping the chamber pressure and

for insertion of an internal gunpowder fusee.

A charge of 8 lbs. of alcohol and approximately 12 lbs. of liquid oxygen was placed in the tanks after the motor had been fastened to the stand. Participants retired to their proper stations. The command to fire was given. The internal fusee did not ignite. A hurried check of the wiring revealed nothing wrong with the circuit. Again the experimenters took stations and the ignition was tried. Still no telltale smoke from the nozzle to indicate the fusee had ignited. Now the cap had to be removed from the oxygen tank lest its internal pressure build up to a dangerous figure. The wiring was checked more thoroughly and it was found the fault was in the battery which had run down to the point where it would not supply enough current for ignition.

Puzzling Explosion

Enough oxygen was poured into the tank to compensate for the losses through boiling. An alcohol-soaked rag was tied in front of the nozzle and ignited. When all had returned to safe positions the fuel valves were opened and the motor fired with a roar.

The thrust gauge showed something like 35 lbs. reaction and the chamber pressure was indicated to be only 125 lbs. as against the 250 lbs. pressure with which the fuels were being fed into the motor. A flame of considerable length sung smoothly from the nozzle but it lacked the intensity of the flame of the previous run.

For 13 seconds the motor fired with conditions very stable, the thrust and chamber gauge pointers remaining stationary. Then, as the watchers thought the run to be about over, there came a deafening report. The pressure relief valve was instantly pulled by Mr. Pierce. From our points of vantage the motor seemed more or less intact although the feed lines had been blown away from the motor. Subsequent examination revealed that the side of the motor away from the spectators had been blasted apart. The extent of the damage is shown in the accompanying photograph.

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Trials of a Rocketor—Months of toil blasted in a second. Power of the unexplained explosion is readily apparent. Note frost on lines and motor.

The cause of the explosion remains somewhat of a mystery. Most of the Experimental Committee is inclined to the belief that when the flame worked back into the chamber it exploded the gunpowder fusee, which had not been fired due to the faulty ignition. Adding credence to this view was the fact that no part of the brass container of the fusee could be located. If this be the case it is easily seen the explosion was not caused by any inherent fault in the design. The low thrust and chamber pressure were undoubtedly caused by "outside burning" and should go a long way toward curing the converts of this theory. At any rate it would be of great interest if a replica of this motor could be subjected to more thorough testing.

Retesting An Historic Design

A replica of the first A. R. S. motor as designed by the Messrs. Pierce and Pendray, had been brought along for more thorough testing. A small aluminum casting with a chamber of egg shape, and having injection ports near the nozzle, this motor had been used in A. R. S. Rockets Nos. 1 and 2. It was enclosed in a sheet metal water jacket. The remainder of the oxygen along with a gallon of alcohol was poured into the tanks. External ignition was used and when fired the motor gave a reaction of approximately 35 lbs. It ran for 48 seconds setting a new duration record. Examination of the motor after the test revealed no important damage.

R. Healy
J. Shesta
For the Experimental Committee.

TIMING AND IGNITION CONTROL

At times it has been found necessary to operate the test stand under conditions where no AC current was available. A six volt automobile storage battery is now used for ignition and clock operation. The fusees are fired directly from the source of supply. However the clock must be supplied with 60 cycle AC at a rating of 8 watts in order that it may be synchronized and maintain accurate time.

Transformer

To operate the clock from the battery an old automobile radio vibrator is tuned to 60 cycles by weighting down the contact arms. The pulsating 6 volt DC from this device is impressed on the secondary or 6 volt winding of a 10 ampere filament transformer. The primary or 110 volt winding is timed with 1 microfarad of capacity to smooth out the ripple. The output of this unit is a very stable source of 60 cycle AC current, rated at 10 watts, and allows the clock to operate very accurately.

Portable

This equipment is mounted in a small box, which can be carried with a strap over the shoulder, and dispenses with the need of an eternal source of current. The device is so connected as to give simultaneous control of the firing and starting of the clock upon insertion of a shorted plug. A reset switch is also provided to reset the clock after the motor test.

Lovell Lawrence, Jr.

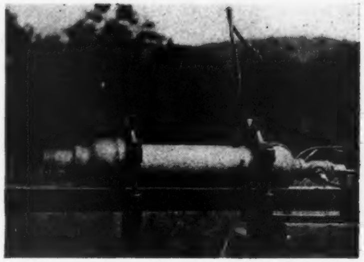
The Africanò Motor

(At the Editor's request Mr. Africano forwards the following information about his design. Performance figures as presented by Mr. Africano were taken from his films of the test run.)

The weight of the motor was 23.5 lbs. (15 lbs. of wrought iron pipe fittings and 8.5 lbs. of refractory lining.) Only 4.5 lbs. of this was needed for strength, the additional weight being used simply as a precaution against explosion, and for lack of machine shope facilities with which to reduce it. The nozzle cone angle was 6 degrees, the diameter varying from 15/16 inch at the throat to 1-½ inches at the mouth. For expansion to atmosphere pressure (14.7 lbs. per sq. in.) this required a chamber pressure of about 172 lbs. per sq. in gauge. The actual pressure averaged about 166 lbs. per sq. in.

The maximum reaction was estimated to be 280 lbs. (extrapolated since the reaction gauge was calibrated for only 200 lbs. at 3/4 turn, and the indicator hand was stopped at the full turn by a protecting pin.) The average reaction for the 12 seconds of combustion was 184 lbs. during which 1 gallon (6.8 lbs) of denatured ethyl alcohol (11,00 B. T. U. per lb.) and about 7.0 lbs. of liquid oxygen were consumed. Another 2.0 lbs. of the oxygen was ejected and produced some additional reaction for the thirteenth and fourteenth seconds as it struck the hot refractory lining and evaporated, leaving 3.0 lbs. in the tank as the feed pressure was cut off to stop the flow.

The best performance occurred in the 9th second when the jet velocity was calculated to be 7050 ft. per sec. The average effective velocity for the twelve seconds of combustion was 5140



HECHT
The refractory lined motor

ft. per sec. The "index of performance" i. e., the reaction in lbs. per lb. of propellant mixture consumed per second was 220, best, and 167, average.

The interesting phenomenon of standing waves 4.6 inches apart was observed near the nozzle at the time of the highest reaction when the jet flame stretched out the surprising distance of about 150 feet.

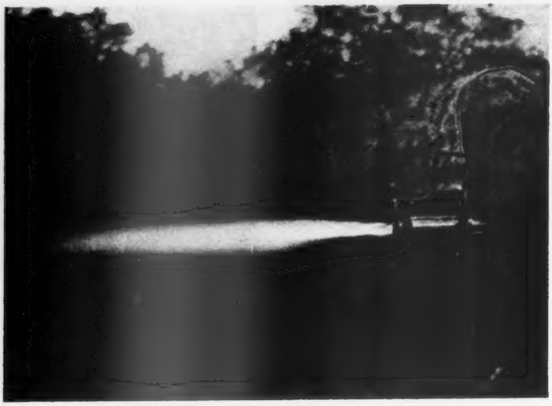
Conclusion: For the first test of a refractory lined motor with no precedent to use a guide in design, these results are about as satisfactory as could be expected. The motor did not reach its best performance since the fuel ran out just about when it began to warm up enough to be delivering 1700 horsepower at 18.7% overall thermodynamic efficiency. The average efficiency was 9.4% when calculated on the same basis used by the writer in obtaining the value of 7% for the 1935 tests.

More tests will be needed, of course, before any final judgment can be reached as to the relative merits of this motor over other types of jet propulsion motors.

Alfred Africano, M. E.

Wyld Motor Retested

Three Runs of August 1st.



HECHT

Wyld Motor in Action—Underexpansion is visible in form of jet near nozzle. Note moisture in air condensing as it is sucked past the oxygen line.

On the afternoon of August 1st the Experimental Committee subjected the Wyld regenerative motor to 3 exhaustive tests at our proving grounds at Midvale, N. J. The tests proved conclusively that a reliable motor for aerological sounding rockets has at last been designed, built and tested. The average thrust for the three runs was about 125 lbs. with tank and chamber pressures of 250 lbs.

Participating in the tests were the Messrs. Fisher, Goodman, Healy, Limber, Pierce, Shesta and Wyld. Dispensing with the usual trench the experimenters sat in cars facing and about 20 feet from the test stand. From this vantage point, protected by the safety glass of the windshields, all controls were operated. Photographic records were taken in the open by H. F. Pierce.

The first test, in which about 12 lbs. of propellants were used, saw the motor fire for 21½ seconds. The violet flame stretched out a distance of approximately 3 feet from the nozzle. The deep roar was interspersed with sudden detonations spaced about 5 seconds apart. This phenomena occurred in all three of the runs, but did no harm to the motor, though shaking the test stand and the cars.

The second run with approximately the same charge lasted for 23 seconds and differed little from the previous test. The concluding run, with the balance of the oxygen and a leaner mixture than previously used, lasted for the surprising time of 45 seconds. During this run the thrust at times reached 135 lbs.

Interesting to note was that when the motor misfired during the tests, due to a defective fusee, the unignited propellants streaming out the nozzle gave a thrust of almost 50 lbs.

R. H.

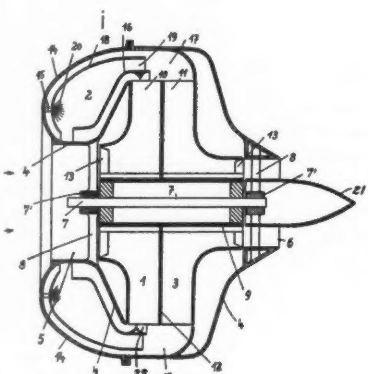
German Patents Rocket Motor

Exhaust Spins Turbine for Blower Drive

That Germany has not lost interest in the possibilities of jet propulsion is testified to by a patent recently issued to Max Hahn of Seestadt Rostock. Of particular interest is the fact that assignment of the patent (No.2,256,198) is to Ernest Heinkel. Mr. Heinkel's factories have been very busy turning out thousands of HE 111's, the most widely used bomber of the Luftwaffe. This rocket motor design, however, is for use in very fast aircraft. Heinkel undoubtedly planned to adapt it to his HE 112 fighter, a very clean, fast airplane.

Similar to G. E. Supercharger

The motor is very similar, in principle of operation, to the General Electric exhaust-driven turbo-supercharger, now in use on the Allison aircraft engine installed in many of America's fighting planes. Dr. Sanford Moss, in a lecture before the Society some time ago, outlined the development of this supercharger. The G. E. device operates as follows: The engine's exhaust gases are led through manifolds to a nozzle box where they are used to spin a turbine wheel at a very high rate of speed. The turbine is fastened to one end of a shaft and a blower or impeller is fastened to the other end. In operation the blower, driven by the turbine, sucks in and compresses large quantities of air which are then blown through the carburetor to the individual cylinders of the engine. A brief glance at the Hahn patent drawing will show the similarity in working cycles.



Max Hahn's Rocket Motor

Operating Principles

The blower **1** and turbine **3**, which are separated by wall **12**, rotate with tube **9** fastened in turn to shaft **7** operating in bearings **7'**. This unit is started by blowing compressed air on the blades or vanes of blower **10** and turbine **11**. The rotating blower sucks in air through the forward opening **5** and compresses it before discharging it into the intermediate mixing chamber **17**. Here part of the air is branched off through the passage formed by walls of motor **4** and **16**. It then passes into combustion chamber **2** where it is burned with gasoline sprayed in through nozzles **15**, of which there are a great number. The combustion chamber, annular in shape, is formed by the space between two sheet metal shells **16** and **18**.

The hot products of combustion emerge from chamber at restricted opening **19** and mix with the balance of cold air which has meanwhile flowed between walls **18** and **14**. The result-

diluted mixture is then directed through the turbine 3 and emerges through annular exhaust 6, giving a jet propulsion effect. A streamlined flow stabilizer 21 fills the center of the exit; it is supported by spider 8. The combustion chamber is supposed to be kept cool by the cold air flowing through the spaces outside the chamber.

It seems readily apparent that a large portion of the energy released by the combustion will be needed to operate the blower by way of the turbine. This has been the great obstacle in the way of designers of gas turbines. The mixing of hot gases with cold air; the friction in passing through the turbine and the circuitous path followed would indicate a low jet velocity. It is difficult to see how this device could be used effectively or efficiently.

These objections may explain why, although the patent was applied for over two years ago, no Nazi warplane has yet been seen using this rocket motor.

Several of this country's aircraft manufacturers are now experimenting with engine exhaust jet propulsion. While it has been known for some time that stacks pointed directly backward do add appreciable thrust, actual research to carry this effect to a maximum has only begun recently. By gradually narrowing down the exhaust manifold the velocity of the gases of combustion is increased. Thrust augmentation by means of tubes surrounding the exhaust nozzle is also being tried. We hope to go into this subject more completely in a future issue.

INTERMITTANT JET MOTOR

Rocket motors fall into two distinct classes. Most familiar to rocket enthusiasts is the continuous combustion type as exemplified by those recently tested by the American Rocket Society and reported on in this and the preceeding issue. The second type, in which the firing is intermittent, giving separate impulses, seems to hold interesting possibilities. Mr. David T. Dobbins of California forwards some interesting data on an experimental motor of the intermittent type. His tests were carried on some time ago at the University of California.

Specfiications: Dimensions — 6″ diameter x 10″ long combustion chamber.

Fuel—100 octane aviation gasoline.

Average thrust 4 lbs.

Average firing frequency=3.5 cycles/sec.

Firing time=0.071 sec.

Charging time=0.211 sec.

Supercharger pressure=6 lbs/sq/in.

Maximum chamber pressure=75 lbs/sq/in.

Gasoline consumption=0.00133 lbs/sec/lb thrust. Fuel consumption readings were taken while a leaky gasket allowed the fuel to drip quite profusely on the ground.

As the above experiment was conducted with air the thrust derived was quite low. It would be interesting to observe what improvement in performance would be made if liquid oxygen were to be used rather than air, and higher chamber pressures employed.

Mr. Dobbin is at present working on an improved model of this early design, using butane in the place of gasoline.

The Rocketor's Primer

INTERNAL COMBUSTION AND THE ROCKET MOTOR

First of a series of brief outlines intended to acquaint the newcomer with, and remind the older members of, some basic facts necessary for an understanding of rocket power, its problems and applications. Readers are urged to consult the appended list of articles and books for a more complete knowledge of the subjects.

The rocket motor is a heat engine of the internal combustion type. As such its operation is governed by the same laws of thermodynamics which cover the action of the more commonly used Otto type or 4 stroke cycle engine. In both cases a fuel is burned within a chamber and the pressure of the resultant gases is converted into useful work. Instead of forcing a piston downward in a cylinder the rocket motor utilizes the pressure to impart a high velocity to the exhaust.

Combustion

Combustion may be defined as the rapid combining of chemical elements in the presence of heat. Fuels used today, such as alcohol and gasoline, are comparatively unstable fluids, eager to unite with oxygen to form stable compounds. In the presence of free oxygen they need but little externally applied heat to bring them to the kindling point at which combustion occurs. Once started this action continues of itself until the supply of either fuel or oxygen is exhausted. As the combustion progresses large quantities of gases are formed. In the case of the two above mentioned fuels the products of combustion are carbonic acid gas and water vapor. The chemical reaction is accompanied by the generation of much heat.

Heat

According to the generally accepted Kinetic Theory of heat; temperature is the measure of the internal or molecular energy of a substance. The molecules, or particles of matter of which all substances are composed, are said to be in a state of violent motion or vibration. In the case of solids and liquids this motion is restricted into definite paths but in gases the molecules move about freely and are limited in motion only by collision with other molecules.

Heat is energy in transfer, molecular activity being imparted from one substance to another or being converted into another form of energy. A heated object tends to expand; when heat is taken or lost from an object its molecular activity diminishes and to us it has cooled. When the chemical reaction of combustion takes place the molecules of the resultant gases are in very violent motion i. e., they are very hot. How hot will depend on the heat content of the fuel used.

In selecting a fuel for jet propulsion high heat content must be a foremost consideration. In hydrocarbon fuels this latent heat energy has been stored by nature from the sun's rays. The unit of heat measurement used in engineering work is the British thermal unit.

One B. t. u. is the amount of heat needed to raise the temperature of 1 lb. of water from 63 deg. to 64 deg. F. Also used is the Metric unit termed the calorie. One calorie is the amount of heat needed to raise 1 gram of water from 14.5 deg. to 15.5 deg. C. One B. t. u. is equal to 252 calories.

Work

The principle of the conservation of energy states that energy can neither be created or destroyed, but may be changed from one form to another. The first law of thermodynamics applies this principle to the statement that heat may be converted into work and work may be converted into heat. If 1 B. t. u. were to be applied to a perfect heat engine we would get a return of 778 ft/lb of work or mechnical energy. In practice the most efficient engines known get but 350 ft/lb per B. t. u., while most engines give only 50 to 200 ft/lbs per B. t. u.

The mechanical equivalent of heat was first measured by Joule in 1840. Modern experiments have placed this value to be one calorie equals 4.185 joules. For rocket motor work we are concerned with changing B. t. u.s into thrust in ft/lbs/sec.

Pressure

Heated gases will try to expand and if confined in a closed or semi-closed chamber will exert pressure on the walls of the chamber. Zemansky defines pressure as the average rate of change of momentum due to all the molecular collisions made in a unit of area. Pressure is what we are after—it can easily be converted into work. The amount of pressure developed from a given amount of fuel will depend on the heat content of the fuel, mass of gas produced by combustion, completeness of combustion and extent of confinement. Other things being equal it may be stated that the higher the pressure the greater will be the jet velocity.

Rocket Thrust

The thrust available from a rocket motor is determined by two factors, the weight of exhaust gases and their velocity. Obviously we have to keep fuel consumption and thus jet mass flow down to as low a figure as possible for economy. Clearly then jet velocity is the all-important factor in the efficiency of a rocket motor. The designer must strive, therefore, to have combustion as complete as possible in the chamber to give the maximum amount of gases and the maximum degree of heat and pressure to these gases before they are ejected out through the nozzle.

Efficient Combustion

For maximum efficiency in combustion and subsequent peak motor performance the following conditions should exist:

1. Fuel and oxygen should be injected into the chamber in a very finely divided state and these particles in very close contact with each other. The vapor given off the surface of the fuel burns, the liquid itself will not burn. A spray of minute droplets presents an enormously greater surface that a solid stream and its combustion rate is correspondingly increased. In this state less energy will be needed to bring about the chemical combination and more energy wil be given out in the form of heat and pressure.

2. Mixture ratio must be correct. An improper mixture of fuel and oxygen will take longer to burn completely and

will still be in the process of combustion when ejected through the nozzle. In practice we have found motors emitting long tongues of flame have low jet velocities and low thrust. The common gasoline engine loses about 1/3 the latent energy of the fuel because the gases are still burning while going out the exhaust. Rapidity of combustion will only be realized with correct mixtures.

3. There should not be excessive loss of heat energy through the chamber walls. An overcooled motor will not operate as efficiently as one whose temperature is high. The motor's heat will assist in vaporizing the fuel and increasing combustion rate. The regenerative design, in which heat loss is brought back in the form of vaporized fuel, has shown very satisfactory results.

Chamber Size

The chamber of the rocket motor motor should be just large enough to allow for complete combustion. If too large there will be loss of heat and pressure inside the motor, if too small energy will be disappated outside the nozzle. Wall surface should be as small as possible for a given volume. A spherical chamber has 1/3 less wall area than a cylindrical chamber of the same volume. Volumes of similar cylinders increase as the cube of their diameters while wall surfaces vary as the square of their diameters. This leads to the belief that larger motors will be more efficient.

Efficiencies

Efficiencies figures are usually worked out through intricate formulas from a variety of theoretical and unknown conditions of combustion in the chamber. When combustion of a hydrocarbon takes place in a cylinder the pressure actually developed falls far short of the pressure computed from the theoretical effects of the heat produced. Designers will be disappointed if they set their expectations on theoretical calculations based on heat content of fuels. At present the most practical measurement of efficiency is the ratio between the mass flow in lb/sec and the thrust in lbs/sec.

Nozzles

The function of the rocket motor's nozzle is to convert the pressure existing in the chamber into high jet velocity. Bernoulli found that where gasses or fluids were passes through a restriction there was a drop in pressure accompanied by an increase in velocity. The Venturi tube is a practical application of this effect and the rocket motor nozzle should be a modified Venturi to convert the high pressure of the gases into velocity.

ARTICLES IN ASTRONAUTICS

Construction of Rocket Vehicles—C. Fitch No. 7

Leaves From A Rocketeer's Notebook—G. E. Pendray No. 25

Theory of Rocket Operation— J. Shesta No. 30

Empirical Rocket Design Formulas— A. Africano No. 34

Simplified Expression for Jet Reaction—R. Uddenburg No. 34

Rocket Motor Efficiency — A. Africano No. 37

Thermal Efficiency Overemphasized — J. Shesta No. 44

Prof. Yellot on Nozzles—No. 45

The Rocket Motor—P. Van Dresser No. 33

The Rocket Combustion Motor—E. Sanger No. 35

Problems of the Reaction Engine—A. Ananoff No. 48

Standard College Texts on Heat Engines, Thermodynamics and the Chemistry of Combustion.

The Rocketor's Workshop

A Department Devoted To Shop-Talk, Ideas, Devices

"LUCITE" FUEL TANKS

By Charles T. Piecewicz

With an increasing shortage of basic metals, due to defense activities, the use of plastics is becoming a necessity in many fields. Quite aside from the fact that metals are becoming more difficult to obtain "Lucite" tanks have one great advantage over metal tanks. "Lucite" is a crystal-clear hard resin with an approimate tensile strength of 8000 lbs/sq/in.

The transparency of this plastic eliminates the necessity for using measuring devices to determine the consumption of alcohol and liquid oxygen. The change of height of the propellants in the tanks can be readily seen and photographed while a rocket motor is firing on the test stand.

Alcohol will not attack "Lucite" to any extent. It has the peculiar property of increasing its modulus of elasticity when immersed in liquid oxygen. A piece of "Lucite" when thrown on the floor under normal conditions gives a dull ring, after having been immersed and cooled in liquid oxygen it gives a clear pronounced ring similar to that of steel. However, it does not shatter.

Construction of Tank

The actual construction of the tank, shown with the writer who conceived the idea, was done by Mr. N. Carver. Mounted to the unit is a hydraulic ram and gauge for testing the tank. This particular tank has a 1/8" wall. It withstood 400 lbs. pressure as read on the gauge. The tank was not tested to destruction since its intended working limits are well below 400 lbs.

Thermal Expansion

The "Lucite" was submitted through the courtesy of E. I. Dupont de Nemoors and Co.; Arlington, N. J. It is available in many different tube diameters and wall thicknesses. Knowing the pressure with which one wants to work, diameter of tube and its tensile strength, the ordinary formulas for thin walled cylinders will give the proper thickness.

Since plastics have a different thermal expansion than metals the including of a "Lucite" rod through the center overcomes any difficulties which may arise when using liquid oxygen. Top and bottom caps are made of the same plastic, a thin metal piece is

(Continued on Page 16)

Mr. Piecewicz and "Lucite" Tank

placed on top for support. The protruding "Lucite" rod is screwed down with "Lucite" nuts. An auxiliary tube around the liquid oxygen tank will serve as an air jacket. This will prevent the outside tube from frosting up too rapidly.

Transparent

At a recent Photographic Committee meeting of the American Rocket Society, the author showed a film of some recent Society motor tests and a portion of the film included Mr. Carver's test stand. The tanks were made of "Lucite". The author's hand was plainly visible when moved behind the tank to illustrate its transparency.

As an experimental aid in rocket research this clear plastic will undoubtedly help to simplfy test stand designs. Its light weight may help also make it practical for use in tanks for actual sounding rockets.

Mr. William Hall, of Gloversville, N. Y., is the inventor of a metal flight tube, for the vertical launching of powder rockets. He writes as follows:

" I have been conducting experiments for the past 5 or 6 years and have found the Rocket Flight Tube to be very satisfactroy."

"The flight tube is 15 feet high, 9 inches in diameter, and is constructed of galvanized iron. Ports are placed at different heights to light the rockets. At the bottom of the tube is a circular wooden disc weighted down with gravel and cement. Total weight is about 100 ibs."

"I have found there is no danger from sparks, and less danger before the rockets leave the tube. When the rockets reach the end of the tube they have exhausted their maximum power, and they will not vary off their course unless there is a strong wind blowing. When shot on still days the rockets do not deviate from the vertical."

THE ROCKETOR'S LIBRARY

ROCKETS THROUGH SPACE, by P. E. Cleator (277 pages) a popular treatment of rockets, their history, how they work and what they promise. Price to members $2; to non-members $2.50.

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of the vast majority of our active members. Newcomers frequently express the desire to take an active part in research but say apologetically, "I don't know anything about rockets."

For the benefit of these members we publish in this issue the first in a series of basic outlines dealing with the various phases of rocket work. Readers are cautioned that a little knowledge is sometimes a dangerous thing, these articles are meant to whet the mental appetite. Suggested reading for a more complete knowledge of each subject will be listed at the end of each article.

Bernard Smith, President of the California Rocket Society, was recently interviewed by a newspaper man. Speaking of a preponderence of theory over actual experimental work Mr. Smith said, **"There is altogether too much academic dreaming about such things as thermal efficiency and mechanical efficiency in gauging results of tests. And there is too much pooh-poohing on the real problems of actual flight."**

"It reminds me of the Wright brothers and airplanes. Scientists said it couldn't be done except on paper. Two bicycle builders didn't know that, however. They just went ahead, built a thing, named it 'airplane' and flew it. That's probably the way it will be with the solution of rocket flight.

"It won't be done by dreaming about trips to Ganymede or by covering sheets of paper with mathematic formulae. It will be done by enthusiasts who —— at their own expense — work out the little problems one by one."

We must say we are pretty much in agreement with Mr. Smith. However we do not believe in going from one extreme to another, from dreaming of interplanetary trajectories to getting one's arm blown off in an explosion due to lack of knowledge of simple chemistry. Basic theory and a certain amount of mathematical work is essential before engaging in experiments.

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ASTRONAUTICS, official publication of the American Rocket Society, is devoted to the scientific and engineering development of the rocket and its application to problems of research and technology. Published by the American Rocket Society, 1 East 42nd Street, New York City. Subscriptions with Associate Membership, $3 per year. **Editor: Roy Healy.**